Cassidy Harding. A User Analysis of the Environmental Finance Center's Water and Wastewater Rates Dashboard Tool. A Master's Paper Proposal for the M.S. in I.S degree. February, 2021. 48 pages. Advisor: Ronald Bergquist

The Environmental Finance Center's (EFC) Water and Wastewater Rates Dashboard is an interactive web-based tool that assists with understanding, bench marking, and assessing a utility's rates, financial health, affordability, and other metrics. The first iteration of the dashboard tool was released over a decade ago and the tool's overall design has remained largely stagnant since. In order to investigate areas of opportunity and room for growth, a user study was conducted via semi-structured interviews of 20 utility managers, who represent the intended audience of the dashboard. Feedback from users on the tool's function, metrics and visuals, was used to create a dashboard enhancement plan. The plan consists of a ranked list of realistic and prudent user-centered recommendations for future improvements to the dashboard.

Headings:

Water and Wastewater Utilities

Systems Analysis

User Studies

Data Visualization

Environmental and Financial Decision-Making

A USER ANALYSIS OF THE ENVIRONMENTAL FINANCE CENTER'S WATER AND WASTEWATER DASHBOARD TOOL

by
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Introduction

Background and Purpose of Work

The Environmental Finance Center at the University of North Carolina at Chapel Hill (EFC) is a non-profit organization focused on providing technological services to aid clients in environmental decision-making. Working collaboratively with utilities, local government officials, and the Environmental Protection Agency (EPA), the EFC delivers applications and financial guidance to influence environmental finance policy for regional and state governments across the United States. One of the EFC's longest running and most trafficked web-based tool is the Water and Wastewater Rates Dashboard, which is the focus of this project.

The Water and Wastewater Rates Dashboard tool is an interactive visual presentation of utility volumetric rates and financial performance indicators. The dashboard's stated design goal is to "assist utility managers and local officials with analyzing residential water and wastewater rates against multiple characteristics, including utility finances, system characteristics, customer base socioeconomic conditions, and geography" (UNC Environmental Finance Center, 2020). Amongst other key functions, the tool allows utility managers to compare their rates with other comparable utilities and assess the demographic qualities of their service area.

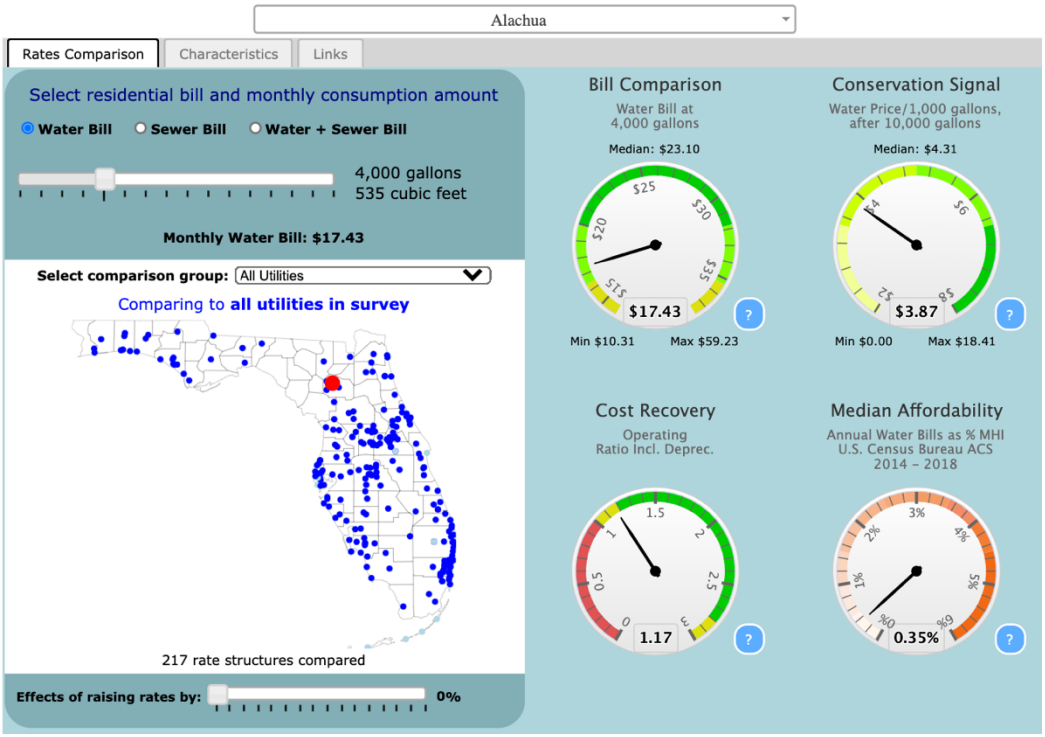

Figure 1. Florida Water and Wastewater Rates Dashboard

Dashboards are funded via annual contracting with individual state agencies. As of 2020, the EFC has designed dashboards for 16 states, and is currently developing contracts with several more. These agreements exchange capital and utility rates information for the creation and annual update of a state-specific dashboard. The yearly nature of the EFC's contracts provides ample opportunity for the evolution and improvement of the dashboard, and yet, the tool's design has remained largely stagnant over the past decade. This is concerning considering the swift pace of advancements in the field of web-based data visualizations. Moreover, other organizations have begun to market similar web-based tools, generating competition for already limited government

funding. In order to remain competitive it would be pertinent for the EFC to enhance its dashboard tool or risk losing its customer base.

This project developed a plan for the improvement and modernization of the Environmental Finance Center's Water and Wastewater Rates Dashboard, based on a localized study of those whose input is most significant—the users.

Overview of Research Methods

According to the EFC's website, the Water and Wastewater Rates Dashboard is aimed at a particular user group, composed of "utility managers and local officials" (UNC Environmental Finance Center, 2020). This ambiguous grouping may or may not accurately reflect the vast majority of individuals who visit the tool's webpage. Further complicating matters, many of the tool's users are not the direct funders of the product (i.e. state and local government agency members) forcing the EFC to account for both its user base and sponsors, who may have diverging needs and requests.

Due to the aforementioned complexities associated with the dashboard's user base, the first phase of this research project consisted of an analysis of the dashboard's users. The goal of this stage was to characterize the tool's user base, using website analytics data from a previous study conducted by Julia Cavalier (Cavalier, 2020). This preliminary investigation was guided by the following question: Who are the tool's users and how does this audience compare to the tool's intended users?

The second phase of this project was focused on illuminating the needs of the users identified in the previous research phase. Five virtual interviews were conducted to

explore how users employ the dashboard tool, in order to assess how effectively the tool addresses their needs and unveil any discrepancies between its initial design and function. Eight EFC staff members with an intimate knowledge of the tool were also interviewed to glean additional detailed insight. The interviews of users and staff served as a platform to offer recommendations for improvements to the tool. Any feedback or insight gained in the interview process was used to create the dashboard enhancement plan, which was the object of the third and final stage of this research project.

The last phase of this project was the creation of a plan incorporating findings from the user needs investigation into a concrete proposal for dashboard improvement. The plan consists of a list of recommendations in priority order. Ranking was based on the number of mentions in the user interviews and subsequent EFC staff input. This dashboard enhancement plan was designed to increase the tool's usability, marketability, and competitive edge, from a user-centered perspective.

Area of Need

Assessing the needs of a product's users throughout the design process is central to the User-Centered Design framework. Many successful organizations, such as IBM and MetLife, utilize this approach to design a variety of products, from database software to website portals (Vredenberg, 2001). Due to the EFC's limited resources and staffing, the Water and Wastewater Rates Dashboard's users have not been regularly studied and the tool's appearance and function have remained largely unchanged since its release. Re-

focusing the spotlight on the users is the path forward to revamping the EFC's dashboard tool and serves as the underlying theme for this project.

Literature Review

Section 1: Information Visualization as a Practice

Introduction to Information Visualization

Over the past three decades, coinciding with major technological developments in internet capabilities and web design, the domain of information visualization has grown in both reach and significance. However, the advent of computers was by no means the point of conception for the field. Long before the formation of the World Wide Web, data visualizations were drawn by hand and used for the same express purpose as they are today—to form mental models of particular ideas or sets of ideas (Spence, 2014). These visualizations existed in a variety of media, from textbooks to posters and maps, designed to facilitate visual exploration, defined by Kelly et al. as the act of "extracting insight from data via interaction with visual depictions of that data" (Kelly et al., 2007).

With the creation of cyberspace, information visualization spread to new platforms. Visuals could be created with virtual tools, connected to live data sources, and interacted with. Card et al. presents a revised and narrowed version of Kelly's definition to represent this shift, delineating information visualization as the "use of computer-supported, interactive, visual representations of data to amplify cognition, or the acquisition and use of knowledge" (Card et al., 1996). According to Ware, this knowledge is procured through three major visualization feedback loops: visual-manual

control, view refinement and navigation, and problem solving (Ware, 2004). Briefly described, these feedback loops represent properties shared by a majority of visualization techniques. The visual-manual control loop refers to the data manipulation cycle of selecting objects and reacting to the resulting occlusion. The next loop, view-navigation, relates to the investigation of expanded, detailed spaces, such as orientation on a map. Combining the previous two loops, the problem-solving loop represents the utilization of the former loops to solve specific problems (Ware, 2004).

Information visualization is much more than just a tool for knowledge attainment. Visualizations are key to big data analytics, making sense of vast quantities of data and communicating efficiently a single message or series of messages. Schneiderman highlights the ability of visualizations to "reveal patterns, clusters, gaps, or outliers in statistical data, stock-market trades, computer directories, or document collections" (Schneiderman, 1996). Additionally, he praises their facility for orienting the user and promoting discovery. As compared to static charts and data sets, creative data visualizations capitalize on users' optical agility. Visualizations have the capabilities to channel exploratory information seeking behaviors, leading to unexpected revelations, often called serendipitous encounters (Foster & Ford, 2003). Mercun and Zumer, in their list of recommendations for library data display, emphasize the potential for visualizations to encourage serendipity. Amongst other boons of visual design, they argue for its employment to help users "overcome large information spaces, build new knowledge, as well as discover and understand relationships and the information space" (Mercun & Zumer, 2016).

1.2. The Environmental Finance Center, and the History of the Water and Wastewater Rates Dashboard

The EFC has taken advantage of the rising prominence of information visualization to market its Water and Wastewater Rates Dashboard. The first dashboard was created in 2006 for the state of North Carolina and was funded by a contract with the NC Department of Environmental Quality (NCDEQ). In the first year of its existence, the dashboard was developed in Excel and was comprised of static graphs benchmarking a single utility's rates and financial performance metrics against other utilities. After the first year of running the dashboard on Excel, the design team purchased the software package Xcelsius, which allowed EFC staff to upload excel files and create interactive graphical displays from a set menu prescribed by the program. Once finished, the program would export a flash file, which was embedded on the EFC's website for customer use. In 2013, due to the sluggishness of running a flash file and an excessive array of embedded data and formulas, the EFC migrated from Xcelsius to an Html5 equivalent run on Ruby on Rails, which is the tool's current platform.

The tool, although slightly different for every state, is comprised of several different visualization techniques, including dynamic dials, maps, tables, and bar graphs. Tracing the dashboard through Schneiderman's Information-Seeking mantra, the user can "zoom" by selecting a utility to analyze, subsequently refining the data to reflect the water and wastewater rates of the specified utility. The information displayed can be further filtered by comparison group (i.e. other utilities within a fifty mile radius, other

utilities in the same census tract, etc.). Finally, through movement of the rates slider and consumption slider, the user can attain "details on demand" relating to the effect of raising rates and/or household consumption on monthly bill affordability, amongst other financial metrics (Schneiderman, 1996).

It is undeniable that the EFC's Water and Wastewater Rates Dashboard is an effective and desirable tool. If the dashboard were failing to inform decision makers and strengthen financial literacy, then contracts would not continue to be renewed year after year, and new states would no longer be expressing interest in the product. Albeit, it may be a sign of stagnancy and lack of innovativeness that the tool's design has remained largely unchanged over the course of the past decade. The tool has aged, but the tool designers do not necessarily know if their predicted user end needs have diverged from the users' actual needs. Without regular user feedback and iterative improvement, even a profitable tool can senesce into obsolescence.

Section 2: Consequences of Mismatched User and Engineer Visions

Failure to pair design goals with user needs can be detrimental to a product's success. Regardless of a tool's modernity, novelty, or pizazz, if it does not adequately meet the needs of the users, then its longevity and saleability is limited. Souder and Song, in their study on design and marketing strategies, found that performance superiority, technological prowess, and radicalness, were inversely correlated with commercial success for small organizations in the United States (Souder and Song, 1997). On the other hand, user compatibility was observed to have the greatest positive association with product adoption. Customers cited a preference for "technologically familiar components,

whose performance simply met the specification rather than exceeding them." Unfortunately, many organizations have found out this truth firsthand. Here this paper will discuss two product launch blunders and the lessons learned from each, to illustrate why this user-centered dashboard improvement project is both opportunistic and necessary.

2.1 HP Touchpad

In 2012, Hewlett-Packard released what was envisioned to be a star substitute for the iPad—the HP Touchpad. However, less than seven weeks after its unveiling, the product was taken off the market, a considerable public flop. A variety of factors contributed to the Touchpad's swift demise, ranging from a delay in its release and the resulting lack of press coverage, to striking similarity in design and price to its Apple competitor. The crux of the product's downfall, however, lay in HP's misunderstanding of user needs and priorities.

A primary theme that HP overlooked is the notion that a tablet, at its core, is a consumptive device more so than a work device. Customers are largely motivated to purchase these items for entertainment, illustrated in the massive growth and profitability of the ITunes app store. From the Touchpad's origin, HP made the decision to turn its focus away from application availability. Compared to the over 90,000 apps accessible to the IPad, the Touchpad had only 300 available apps (Jowett, 2016). Further exacerbating matters, baked into this design choice was an internal infrastructure that had limited capabilities for the creation of new apps.

In addition to their underrepresentation of amusement in the tablet's function, HP failed to correctly prioritize efficiency and product thinness (Sinha, 2019). Users widely preferred the narrower shape of the iPad to the Touchpad, due to ease of storage, a quality not taken into account in the design process. Adding to the inconveniences associated with the product, was its unique WebOS software. To cut costs, HP took corporate shortcuts in its technological framework, resulting in an extremely slow operating system (Chen, 2012). A greater focus on the user, could have informed and altered decision-making during the engineering process of the Touchpad, illuminating the importance of loading speed, size, number of applications, and other product qualities, perhaps even reversing the Touchpad's misfortune.

2.2 Microsoft Edge E-Reader

Analogous to the downfall of the Touchpad, Microsoft's electronic reader (commonly referred to as the e-reader) botched its third attempt to enter the market in 2019 (BBC, 2019). This failure can be attributed to two main misconceptions about the e-reader's user-base—prominence of the "reading experience" and download-ability. The former concerned the public's desire for an e-reader that mimicked the behaviors utilized in reading a physical book. Users preferred readers that incorporated the functionality of a novel, such as inking, highlighting, and bookmarking, like those offered by the product's competitors—Barnes and Noble's Nook and Amazon's Kindle. Microsoft's e-reader was void of all reader experience characteristics, diminishing its competitive edge. Reinforcing the product's already poor prospects, the e-reader lacked the ability to download books on the edge app (Grossman, 2019). This internal design choice greatly

inconvenienced readers, limiting the e-reader's user-friendliness in traveling environments.

Studying the usership of electronic readers prior to the release of Microsoft's e-reader could have reduced the risk of the product's collapse. Obtaining preliminary user feedback on the product design could have highlighted areas of improvement, like heightened interactivity and off-line service, and even reversed the product's market trajectory.

Section 3: The User Study

3.1 User Study Definition

As illustrated in the previous section, understanding a product's users is integral to its market performance. If a product's users are not correctly identified and/or their goals not adequately characterized, then the product will not meet the needs of its audience, leading to its sales languishing. Often times organizations avoid this pitfall by conducting what is known as a user-study. A user study is defined as researching the implications of design on the user, by investigating "user behaviors, needs, and motivations through observation techniques, task analysis, and other feedback methodologies" (Kuniaysky et al., 2012). This type of exploration is concentrated around the concept of user-centered design, in which user views are integrated throughout the product design process and seen as the central influence in a product's outcome (Abras et al., 2004).

3.2 Types of User Studies

Assessing the users of a system is a fundamental practice in the field of Information Science and due to its broad applicability takes on a variety of forms, from prototyping to usability testing. The type of user-study chosen is dependent on the breed of product, the timeline for development, the production environment, and affects the level of researcher interaction and user involvement required for the study. For example, the contextual interview, in which the researcher observes the user interfacing with the product, necessitates a high level of degree of researcher and user engrossment. This presents a trade-off among the detail of data collected and the amount of resources invested (Stokes and Bergen, 2006). On the other hand, the survey method, in which a questionnaire is distributed to several users, demands a limited amount of researcher as well as user engagement, illustrating a concession between data quality and data quantity.

Prior to selecting a type of user-study, T.D. Wilson in his review, "On user studies and information needs", dictates that the researcher must first specify the particular subfield and delineate the aspect or aspects of the information of interest (Wilson, 2006). The subfield of focus for this project is data visualization, and the information of interest is financial data associated with the affordability of utility water and wastewater rates. This information task is cognitive in nature and highly specific, lending itself to interview methodology, which was the strategy employed in this project.

Section 4: Past EFC-related Research Efforts

There have been several studies conducted related to the EFC's work, due to the organization's close professional and academic connections to the University of North Carolina at Chapel Hill. This project was built on this existing body of work.

Prior studies have consisted of a usability study on the EFC's Stormwater Dashboard tool, surveys of utility managers on their planning strategies, analysis of website analytics data to ascertain information on website traffic, and webform testing. This master's project collected a large quantity of qualitative information from utility managers and translated findings into a viable work plan for dashboard improvement. Combining data collection with the development of implementation measures gives the EFC concrete steps towards product enhancement and if executed will provide the users with a heightened visualization experience.

Methodology

Context

It is rare to see a product achieve sustainable market success without iterative improvement and alteration, and yet the dashboard's general design has not significantly changed in the past decade. Although dashboard users have not excessively complained about the product, this technological complacency serves as an opportunity for innovation and creative thinking. Recently, the EFC has experienced a change in management, with the retirement of its previous director and original founder of the organization. Under the direction of its new manager, the EFC has expanded its executive aims to embrace inventiveness and investment in new tools, coinciding well with the ambitions of this project. Permission from the EFC management team was acquired to carry out this study and they affirmed their full support for this project.

Study of user needs and subsequent creation and implementation of a dashboard enhancement plan could benefit both the tool's users (i.e. utility managers and local government officials) and the EFC as an organization. Providing the users with a tool that is better suited to meet their needs and the EFC with a dashboard tool that is more competitive and valuable to its customers.

Role of Researcher and Positionality

For the past year, the author has been a technical researcher at the EFC, responsible for the development and maintenance of dashboards, which are coded in a variety of programming languages, including Ruby, JavaScript, and html. In this role they organize utility data, migrate the data into the database, perform calculations on the data to obtain a variety of financial metrics, and manipulate the data into a cohesive format that is pleasing to the end-user. Through this work, they have developed an intricate familiarity with the underlying database and coding framework that forms the dashboard tool. Their intimate knowledge of the tool inspired this project as well as equipped them with the necessary skills to achieve its goals. Since the EFC is their employer, it is prudent to clarify that they are a graduate research assistant with a fixed stipend and do not financially benefit from conducting research on the EFC's dashboards.

Goals and Deliverables

The goal of this research project, as previously stated, was to develop a plan for the improvement and modernization of the Environmental Finance Center's (EFC) Water and Wastewater Rates Dashboard. Past projects concerning EFC's dashboards have not directly focused on the tool or assessed whether the tool is presently meeting its users' needs. By analyzing the dashboard's user-base and drafting a plan for the tool's enhancement, this study paves a path forward for the EFC to cater better to its customers as well as advance the tool's competitiveness, marketability, and profitability.

In order to more clearly define the scope of this project, the research goal is sub-divided into the following study objectives:

1. Characterize the users of the EFC's Water and Wastewater Rates Dashboard.
2. Assess the tool's primary functionality from the user's perspective.
3. Identify the user's needs and determine which needs the dashboard fails to address.
4. Create a plan for the revision of the dashboard.

Sampling Methodology

According to the EFC's website and research conducted by Julia Cavalier, the dashboard tool's usership consists mostly of local government officials and utility managers (Cavalier, 2020; UNC Environmental Finance Center, 2020). Due to contact information availability and the ambiguity of the title "local government official", this project focuses solely on the dashboard users affiliated with water and wastewater utilities. The EFC maintains a database of utility manager contact information for utilities that are present on each of the dashboards. This database was used to obtain a sample of five individuals to be interviewed in the next research phase.

In order to reduce the bias of this convenience sample, random numbers were generated, excluding repeated values, to select utility contacts out of the database. Sixty utilities were chosen and sent a recruiting email, to account for a 66% nonresponse rate. Two weeks after the first round of emails were sent, only one utility manager had replied, so sixty more utilities were randomly chosen and sent a recruiting email. This process

was carried out twice more, with the aims of reaching the sample size of twenty. However, this sampling methodology resulted in a low response rate and consequently the sample space was reduced to five utility affiliates. The remaining contacts were selected via convenience sampling. Ten utility managers that had historically responded to email correspondence from the EFC were sent a recruiting email and four of them agreed to participate in this study.

Eight EFC professionals were selected for the staff portion of the interview proceedings. These staff members were identified based on their familiarity with the dashboard tool. Individuals that had the most experience creating, editing, and presenting the tool were chosen, as these subjects have the greatest knowledge of the tool and likely the most striking suggested edits.

Interview Utility Managers and EFC Staff

A series of virtual semi-structured interviews were conducted with each utility manager in the sample. These interviews were thirty minutes in length and carried out individually over Zoom. As Barriball and While note in their review of research methodologies, the semi-structured interview is a common data collection tool that offers an array of benefits (Barriball and While, 1994). Interviews promote detailed exploration of respondents' opinions and clarification of respondents' replies, while also confronting the issue of non-response error. As anticipated, these interviews facilitated organic information exchange, probing into novel ideas and obtaining design recommendations.

To sufficiently acquire feedback on the dashboard tool, the interviews addressed, but were not limited to, the proceeding questions:

How did you discover the dashboard tool?

How often do you visit your state's dashboard?

Why do you use the dashboard tool?

What features on the dashboard do you find most useful?

What features on the dashboard do you find least useful?

How would you like to see the dashboard tool improved?

Explore Trends and Draft Dashboard Enhancement Plan

Once the interviews were concluded, the results were analyzed by creating an affinity diagram of the concepts uncovered (see pages 22 and 23, categorizing the study findings into broad categories (i.e. user needs, dashboard failures, dashboard successes, recommendations) and refining the categories systematically. Thematic content analysis of the interview transcripts was also executed to uncover emergent themes buried in the contextual inquiries. Then, referring to the affinity diagram and collection of overarching themes, a list of dashboard failures and mismatches between user needs and dashboard performance was compiled. Based on extrapolations from this list and dashboard recommendations explicitly stated by the users, a dashboard enhancement plan was drafted.

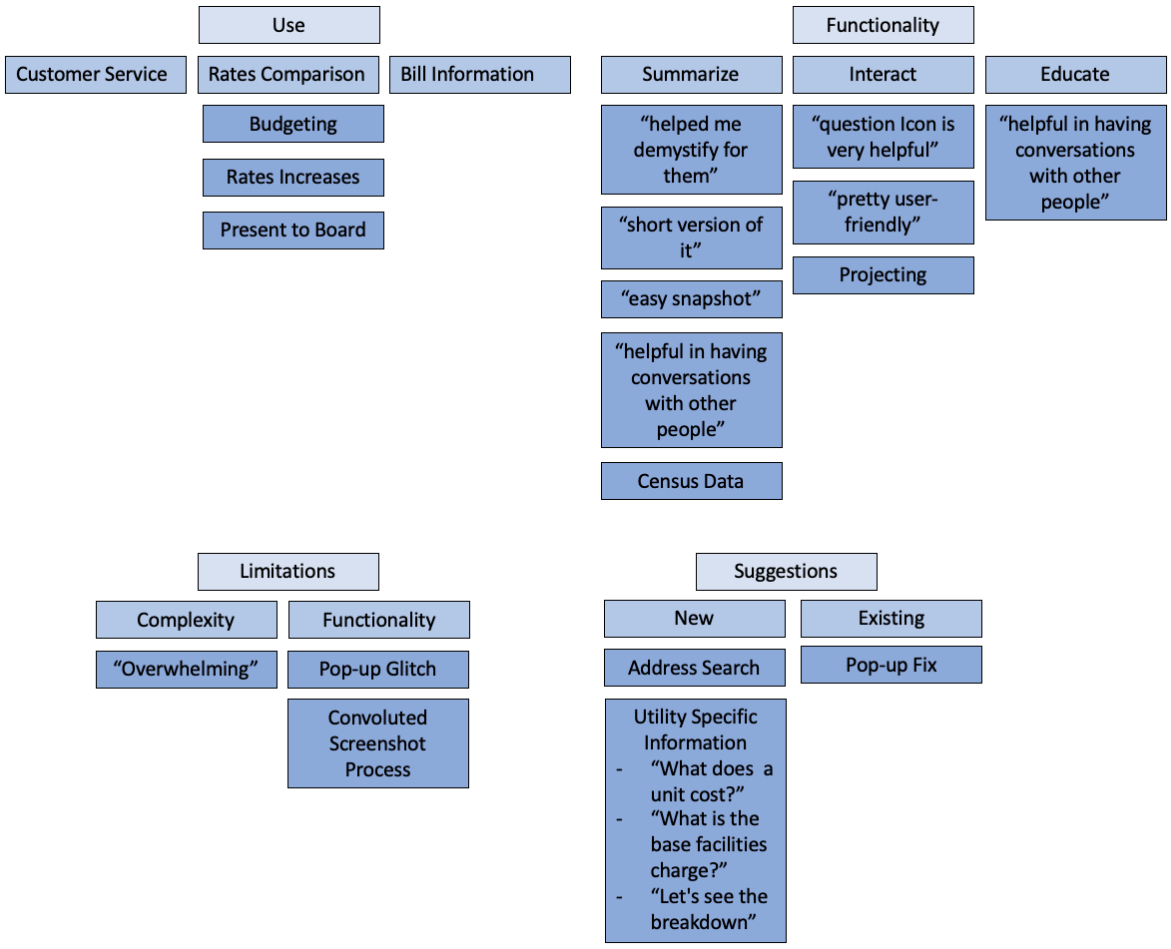

Figure 2. Affinity Diagram of User Interviews

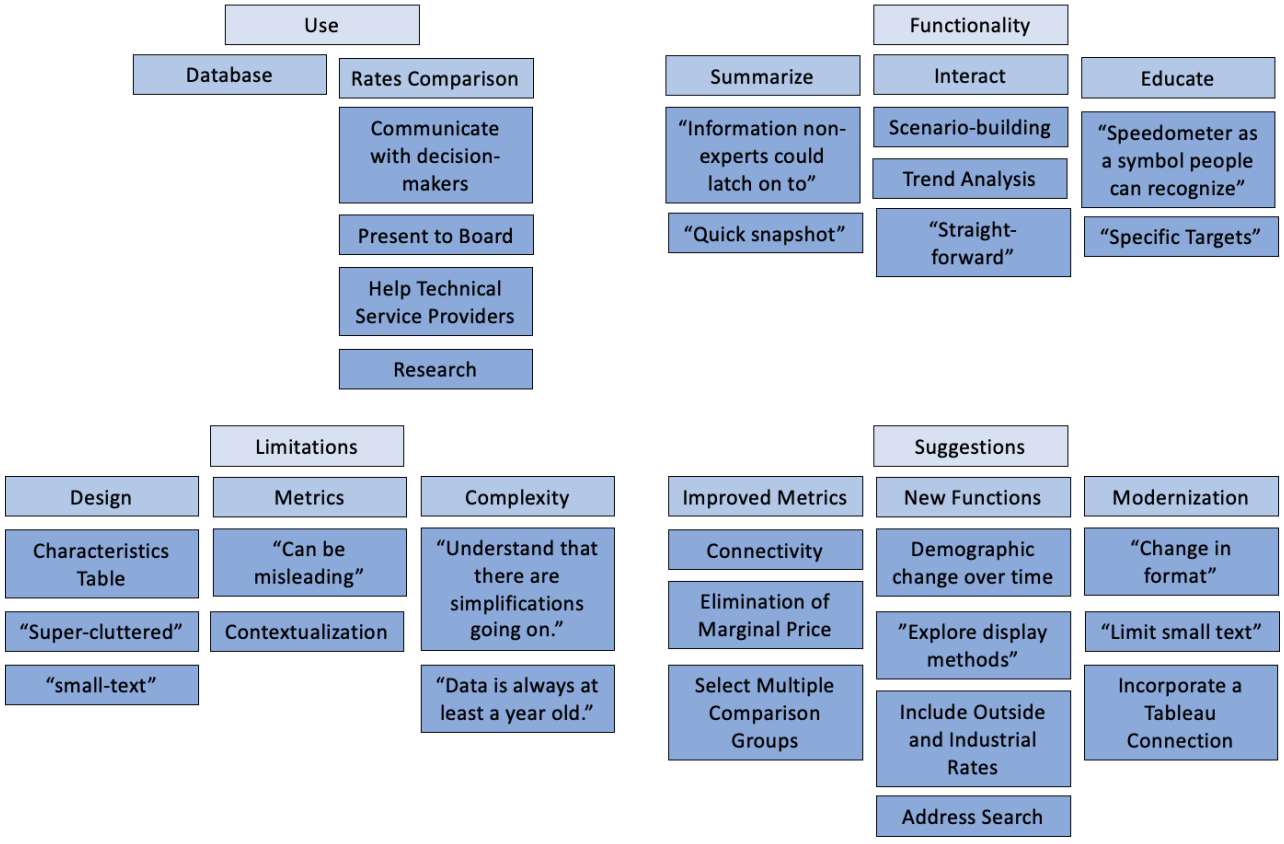

Figure 3. Affinity Diagram of Staff Interviews

The dashboard enhancement plan took into account revelations from the user study to form an agenda of concrete suggestions for dashboard improvement. The document was written keeping the principles of feasibility and sustainability in mind. Suggestions that were hypothesized to take greater than six months of work to implement or require an excessive amount of data cleaning or collection time were not included in the plan. It is intended to be used as a guide to the evolution of the dashboard in real time.

Project Evaluation

Discoveries from the user study and the dashboard enhancement plan will be presented formally to EFC management staff upon its completion to illustrate relevant project findings and obtain valuable feedback. Following the presentation, the management team and the researcher will discuss evaluation techniques. Since the researcher's employment contract with the EFC expires in May of 2021, they will likely not be a staff member when the implementation of the plan takes place, thus it is of great importance that the project evaluation strategy is clear and replicable. It is suggested that EFC staff members email follow-up surveys to each of the utility managers that participated in the interview proceedings. This survey will assess the users' attitudes towards the changes made to the dashboard, with positive results indicating a successful project outcome.

Impact and Limitations

Impact

Since the Water and Wastewater Rates Dashboard was established fifteen years ago, this project explores the areas of disconnect and overlap between the design goals of the EFC web development team and the needs of dashboard's users. Coupled with the rise of similar internet tools and a shift in corporate values to emphasize avant-garde thinking, this project fills a needed and pertinent void. Study of the dashboard's user base illuminated discrepancies that exist between the EFC's assumptions of what the users want, and what the users actually desire from their product, thus providing a blueprint for a new dashboard that will better serve the product's users.

Creation of a dashboard enhancement plan will inform future decisions in regard to the tool's design and function, inherently improving the tool's marketability and competitiveness. Moreover, implementation of this plan will result in a tool that effectively meets the user's needs and more compellingly communicates rate affordability and conservation metrics. An improved dashboard tool, that fulfills its designated purpose of aiding in 'understanding, benchmarking, and assessing a utility's rates, financial health, affordability, and other metrics', will lead to more educated decision making by local officials and utility managers (UNC Environmental Finance Center, 2020).

Limitations

Sampling Method

One of the main weaknesses of this project is the use of the convenience sampling method. Theoretically, to have an entirely representative sample of the dashboard's users, the IP addresses of every individual who visited a state's dashboard in the past year would need to be traced and their contact information obtained. Obviously, this is not realistic and violates a host of privacy regulations. Utilization of the EFC's utility manager contact database was the best alternative. Although, utility managers do not represent all dashboard users and the database does not contain every utility manager for every state that has a dashboard, a convenience sample ensured access to a set of users that are known to interact regularly with the dashboard.

Convenience samples are not ideal in scientific practice due to their "vulnerability to severe hidden biases" (Etikan, 2016). In order to limit the influence of bias on the sampling process, the sample was selected randomly from the contact database. Unfortunately, the vast majority of the individuals contacted for the interview phase of the project did not respond to email outreach. The many stressors, related to Covid-19, racial injustice, climate change, and economic turmoil, that are currently rocking American society likely inhibited my ability to get in touch with utility managers and obtain their consent for participation in this project, resulting in non-response bias. Despite persistent efforts to recruit utility affiliates via random sampling, this method was largely unsuccessful.

Another weakness associated with this methodology is the size and homogeneity of the user sample. Four of the five users sampled were affiliated with North Carolina utilities, biasing the sample geographically. Additionally, with representativeness in question, the suggestions provided by users may not adequately reflect the needs and desired of users at a larger scale. With these limitations in mind, the user interviews were still extremely valuable in providing relevant input for the dashboard's improvement and concrete recommendations that will improve the user experience as a whole.

Resources Available

As with the implementation of any business plan, a significant amount of funding and human capital is required. Amidst a global pandemic and recession, the EFC may not have the financial backing or trained staff to carry out the dashboard enhancement plan. Furthermore, management may decide to focus on developing novel tools rather than utilizing company resources to improve existing tools. Recognizing these threats to the plan's execution, the plan was drafted assuming the company's present assets and staffing remain consistent.

The EFC's Water and Wastewater Dashboard is a complex tool with a designated purpose and usership. This project gathered worthwhile user feedback on the tool's functionality and drafted a comprehensive plan rooted in practicality for the dashboard's improvement. If implemented, the plan will advance the dashboard's functions, metrics, layout, and usability, enhancing the user experience and heightening the tool's marketability.

In future work, the methodologies used in this study can be applied to assess other products marketed by the EFC, such as the Revenueshed Analysis tool or the Financial Resilience Dashboard tool.[1] Ideally, this project will also serve as an inspiration to the EFC design team, introducing consistent collection of user-feedback throughout the product design process. Highlighting the importance of keeping the user involved in every step of a product's iterative evolution.

[1] For more information on the Revenueshed Analysis tool, see (Harding, 2020).

Results

User Interviews

Of the five users interviewed, all were satisfied with the dashboard tool's present design. One user indicated the dashboard is "extremely helpful, so if you want to get a good idea of what a utility is charging on average, it is a good way to get that ballpark figure by going to one spot and it kind of gives you an easy snapshot of what they got going on". Another said about the tool "I think you have made it, especially for a non-techy, pretty user-friendly". Few criticisms were made by the users and critiques that were made were largely related to small usability changes, such as the placement of a warning pop-up or the ability to quickly export print screens of the tool.

When asked what they most often used the dashboard for, each user cited variations of the same response—to compare rates with other utilities and present that information to justify rates decisions to their respective boards. This standard reply mirrors the outlined design goals of the tool, as stated on the EFC's website, to "assist utility managers and local officials to compare and analyze water and wastewater rates against multiple characteristics, including utility finances, system characteristics, customer base socioeconomic conditions, geography, and history". However, the tool has additional functionalities beyond bill comparison, such as providing demographic information to contextualize rates data and visualizing fiscal metrics as indicators of

utility health. These components were rarely mentioned be users, and when explicitly asked if they ever referenced dials on the financial benchmarks tab, four of the five users answered no. With two of the three tabs under-utilized by a majority of users sampled, it is unclear whether users employ the tool to its full capacity.

Staff Interviews

Comprehensively, the staff interviews were more critical in nature than the user interviews. Negative language was more prominent in staff feedback describing the dashboard tool than in the feedback provided by users. This is not surprising, as staff have a greater knowledge of the dashboard's limitations and many had been involved in the regular cost-benefit analysis required for dashboard decision-making. Their main critiques revolved around outdated design, the controversiality of the utilizing Median Household Income (MHI) as an affordability metric, and the all-around crowdedness of the characteristics tab. One staff member noted "I want to do away with the characteristics tab, it is old and it is ugly". Another staff member stated that they would like the dashboard to be "more modernized and changed in that format". These sentiments were repeated in every staff interview.

The staff interviews produced a lengthy list of suggestions for the improvement of the dashboard. Many of the recommendations were too ambitious to be considered in the near future. The ideas ranged from an address search for users to find utility information specific to their location, to compiling all of the state dashboards into a master dashboard. Only suggestions that could be realistically incorporated into the dashboard within a six month time period were included in the dashboard enhancement plan.

Dashboard Enhancement Plan

The following plan ranks suggestions in order of importance and ease of implementation. Importance was measured based on frequency of appearance within the contextual inquiries and expected impact on dashboard users. Ease of implementation was assessed based on estimated time required to implement each recommendation.

1. *Set a designated number of seconds for the raise rates warning textbox to appear.*

   Currently, when a user moves the rates slider, a pop-up appears that alerts the user to the limitations of calculating the revenue impacts of rate increases. The pop-up only disappears when the user refreshes the page, which sets the rates slider back at 0%. This creates a tradeoff between interacting with the rates slider and viewing the map of utilities. Programming the pop-up to disappear after ten seconds would allow for the user to be alerted without occluding the user's view of the map.

2. *Introduce a button that allows the user to take a snapshot of the dashboard and save it as an image file.*

   Screenshots of the dashboard have often been used by utility managers to present rates information to their boards. There is not a mechanism presently on the dashboard that easily facilitates the download of dashboard pages as image files. Users have to go through the clunky process of utilizing the computer print screen function, which is prone to capturing too much or too little of a webpage, and subsequently saving the file in the default format prescribed by their device. Creating a button to save the dashboard screen, with the option to download as a

.jpeg, .png or .pdf, would eliminate this arduous procedure all together and improve the user experience.

3. *Improve the format of the download data button.*

   The download data button allows for users to download the information underlying the dashboard in text form. Although, none of the users mentioned utilizing this button, it is pertinent that every facet of the dashboard measure up to a certain standard of excellence. Providing the option for users to download data without adequately formatting the information inhibits the function's effectiveness and reflects negatively on the website and by extension the EFC as a whole. To correct this lapse in design attention and advance the professionalism of the page, the download data script would benefit from the correction of all text errors, a significant increase in the spacing between lines, contextualization of values (i.e. inclusion of volumetric units), and removal of all erroneous negative values.

4. *Replace the Median Household Income (MHI) as the standard affordability metric.*

   Median Household Income (MHI) is a highly contentious metric. While MHI is useful in summarizing income at the geographic level, it does not accurately reflect the entirety of the affordability conversation. MHI indicates the income amount that falls directly in the center of a population, without providing any clues to the severity of the discrepancy between those with higher and those with lower incomes. Twentieth percentile income, although also not perfect, better represents individuals with a lower income who share a greater portion of the cost

burden levied by water and wastewater utilities. This data is already collected by the EFC for the CA Water and Wastewater Rates Dashboard and can be duplicated for other states with relative ease.

5. *Change the format of the table on the Characteristics tab.*

   The format of the table on the Characteristics tab, as repeatedly expressed during the staff interviews, is unsightly and archaic. This can be addressed at a minimum by increasing the padding between the text and the sides of the table and enlarging the font. Additional types of data visualizations could be considered for this page as well, such as a line chart illustrating trends in demographic and/or financial characteristics over the past five years, or a bar graph that compares a utility's demographic and/or financial characteristics to the median for all utilities in the selected comparison group.

6. *Ensure that the cost recovery and the bill comparison dial are side-by-side and add a visual cue to indicate that the dials should be used in conjunction with one another.*

   The intended connectivity between the cost recovery and bill comparison dials was mentioned in several of the staff interviews. These dials are meant to be viewed in tandem, as the cost recovery dial provides financial context for a utility's bill amount. Some of the dashboards do not have these dials placed adjacent to one another, undermining the designed combined approach. In addition to assuring that the cost recovery and bill comparison appear next to each other on every dashboard, it would be advantageous to provide a visual indicator to tie the dials together, such as an oblong rectangle surrounding both dials

supplemented by a pop-up that briefly describes how the cost recovery dial can be utilized to contextualize the information presented on the bill comparison dial.

7. *Incorporate non-residential water rates and outside rates into the dashboard.*
   Since the primary audience of the dashboard tool consists of utility-affiliated staff who cater to residential and commercial customers, it would be auspicious to include commercial rates on the standard layout of the water and waste water rates dashboard. This would supply utilities with a greater amount of information to help inform rates changes. The EFC's in-house rates database already contains commercial rates data for many of the states with a residential water and waste water dashboard.
8. *Permit the selection of multiple comparison groups at a time.*
   Presently, users can filter utilities in a state's dashboard by selecting a comparison group (i.e. utilities within a 25-mile radius, utilities with a similar sized service population, etc.). This functionality allows users to compare their rates to utilities with characteristics of their choosing, but does not provide the option of selecting multiple comparison groups at a time, such as 'in my watershed' and 'same ownership type'. Adding the ability to further narrow desired comparison characteristics would give utilities a finer level of detail to aid in their financial decision-making and promote discovery of new trends.
9. *Include an Affordability tab in the standard layout for every state.*
   The standard layout of the dashboard tool consists of a Rates Comparison tab, Financial Benchmarks tab, and Characteristics tab. In the summer of 2020, the

EFC created a pilot dashboard for California, which included a fourth tab entitled Affordability. This page contains three metrics that assess the affordability of water rates for the selected utility's service area: bill relative to twentieth percentile income, median affordability, bill relative to minimum wage. These metrics would be useful for utility managers in other states to inform equitable rates decisions. With the coding infrastructure and census data connections already present for the California dashboard, translation of the Affordability tab to the other states would be feasible.

10. *Modernize the dashboard layout as a whole.*

    The request by multiple EFC faculty members to 'modernize' the dashboard is notably elusive and vague in form. It is difficult to define what exactly constitutes a 'modern' webpage. Increasing line spacing, enlarging the font sizes employed, and heightening the padding between text objects and the iframe are all small steps towards improving the overall aesthetic body of the dashboard. Many more steps will need to be taken, which is where contracting a web design and data visualization expert would be prudent. Employing a professional web-developer, unfamiliar with the dashboard, would supply a pair of fresh eyes to provide recommendations for a revamped dashboard composition.

Discussion and Conclusion

User research is integral to creating designs that are easy and pleasurable to use, relevant to an application's audience, and profitable. Based on the interviews conducted, dashboard users are pleased with the EFC's Water and Wastewater Rates Dashboard standard design, functionality, and metrics. Though the standard dashboard design has changed little over the past decade, when given the opportunity to provide recommendations for the tool's improvement, users had little to say. Souder and Song identified in their study on user-centered design identified user compatibility as the key factor contributing to product success (Souder and Song, 1997). Combining user input with EFC staff feedback to inform a comprehensive dashboard enhancement plan, focused on user-friendliness and small-scale innovativeness provides a feasible step-by-step plan for incremental rather than radical change.

As noted by Abras and colleagues, maintaining user-influence as central to a product's evolution, is key to a product's performance and market success (Abras et al., 2004). In order to ensure the tool continues to reflect the needs of the user, user studies of a similar vein should be carried out on an annual basis, and the dashboard enhancement plan regularly updated to mirror research findings. Future user studies should aim to identify a larger and more varied sample than the sample obtained for this research project. Ideally, these studies would draw from every state that has a Water and

Wastewater Rates Dashboard and would identify utility affiliates with differing professional roles. Transitioning from a staff-heavy deliberative design process to a user-integrated approach will facilitate the provision of web-based applications that more accurately illustrate the needs of the EFC's clients and the tools' target audience.

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Appendix A. Interview Guide for Users

Interview Length: ~20 minutes

Introduction: Hi my name is Cassidy Harding and I am a graduate student at UNC in the School of Information and Library Science. I have been an employee at the EFC for the past year, mainly working on the code that underlies our water and wastewater rates dashboard tools.

For my master's thesis I am obtaining feedback from the dashboard's users in order to assess the tool's general usability and identify potential areas of improvement.

It will be a largely informal interview and your input will be reported anonymously. Before we start the interview, do you mind if I record this for transcription purposes?

So to begin, would you mind pulling up the <insert state here> tool? (https://dashboards.efc.sog.unc.edu/<insert state here> .html) so that you can reference the page as needed. I sent the link in the chat.

1. Have you ever been contacted before by the EFC to provide feedback on the dashboard tool, via a survey or interview?
2. Have you seen the water rates dashboard before?
3. When you first viewed the dashboard tool, what was your initial impression?
4. Have you viewed the tool since?

5. How often would you say that you use the EFC's Water and Wastewater Rates Dashboard?
6. What do you use the dashboard tool for?
7. Would you consider the dashboard tool to be helpful?
8. Do you ever compare metrics to other utilities?
9. Do you ever use the comparison groups functionality?
10. Which dials do you use the most often?
11. Which do you use the least often?
12. Do you understand all of the dials? Are there some dials that are easier to interpret than others?
13. Is there any information on the dashboard that you rarely reference?
14. Have you ever noticed any data inconsistencies or errors in the dashboard tool?
15. If you could redesign the dashboard, what changes would you make?
16. Which components of the dashboard would you remove? Which would you keep?
17. Would you change any metrics, or incorporate any additional metrics?

Appendix B. Interview Guide Adapted for EFC Staff

For my master's thesis I am obtaining feedback from the dashboard's users in order to assess the Water and Wastewater Rate Dashboard tool's general usability and identify potential areas of improvement.

I additionally thought it would be interesting to gather input from EFC staff, to gain your perspective on the dashboard tool and compare your perception of the tool's purpose and areas of enhancement to that of the tool's users.

Before we start the interview, do you mind if I record this for transcription purposes?

So to begin, would you mind pulling up the Wisconsin dashboard, so that you can reference the page as needed. I sent the link in the chat.

https://dashboards.efc.sog.unc.edu/wi.html

1. What would you say is the dashboard's intended purpose? Are there any secondary goals?
2. Do you know if dashboard users actually use the tool for the purpose that you previously identified?
3. Over all would you say the dashboard is successful at achieving the tool's outlined goals?
4. Which dials do you think are most effective at fulfilling the tool's outlined goals?
5. Which dials do you think are least effective at fulfilling the tool's outlined goals?

6. Which dials are easiest to interpret?
7. Which are most difficult to interpret?
8. Have you ever noticed any data inconsistencies or errors in the dashboard tool? What is the general pattern or trend of these errors?
9. If you could redesign the dashboard, what changes would you make?
10. Which components of the dashboard would you remove? Which would you keep?
11. Would you change any metrics, or incorporate any additional metrics?

Appendix C. Recruitment Email for Users

Dear [*insert name*],

My name is Cassidy Harding and I am a graduate student from the School of Information and Library Science at the University of North Carolina at Chapel Hill. I am also a research assistant at the Environmental Finance Center (EFC) and work closely with the web developers responsible for the center's tool designs.

I am writing to invite you to participate in my research study about the EFC's Water and Wastewater Rates Dashboard. I am interested in your input on the dashboard due to your utility affiliation and think you would provide valuable insight on the dashboard's usability. If you are not familiar with the dashboard tool and know another individual at [insert utility name here] that is better suited for this study, please feel free to forward my email on to them.

If you decide to participate in this study, you would be part of a brief (30 minute) virtual interview in which I would ask questions about your use of the dashboard tool and your general thoughts on the tool's layout and general usefulness.

If you'd like to participate or have any questions about the study, please email or contact me at rayh1998@live.unc.edu. I look forward to hearing from you.

Thank you very much.

Best,

Cassidy Harding

Appendix D. Recruitment Email for Staff

Hi [*insert name*],

As you know, I have been conducting user interviews of the Water and Wastewater Rates Dashboard over the past few weeks for my master's project. Since my end goal is to create a dashboard improvement plan, I think it would also be useful to gather staff input (many of the users have given limited recommendations, I think EFC staff might have stronger opinions!).

Would you be willing to meet up next week for a brief informal 30 minute discussion about the dashboard to provide some creative feedback?

Best,

Cassidy Harding